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Some Effects of Post Harvest Handling Methods on Sugars and Inositol in the Sweet Potato (*Ipomoea Batatas* Poir.).

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SOME EFFECTS OF POST HARVEST HANDLING METHODS ON
SUGARS AND INOSITOL IN THE SWEET POTATO
(IPOMOEA BATATAS POIR.)

A Dissertation

Submitted to the Graduate Faculty of the
Louisiana State University and
Agricultural and Mechanical College
in partial fulfillment of the
requirements for the degree of
Doctor of Philosophy

in

The Department of Horticulture

by

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ABSTRACT

The behavior of individual sugars and inositol of Acadian, Centennial, Goldrush and Julian sweet potatoes were followed during normal curing, storage and baking. The "standard" ethanol sugar extraction method and a chloroform-methanol extraction were compared. Determinations of sugar trimethylsilyl derivatives by gas-liquid chromatography were examined.

The chloroform-methanol extraction was superior to the ethanol extraction. Complete recoveries of glucose were afforded by both methods; however, the ethanol extraction yielded maltose whereas the chloroform-methanol method did not.

Deionization of sweet potato sugar extracts and authentic sugars with MB-3 ion exchange resin as reported in the literature was undesirable because only small percentages of sugars were recovered.

Discrepancies were found in the recently published determination of sugar trimethylsilyl (TMS) derivatives by gas-liquid chromatography. Although it was reported that the quantity of the TMS product formed was essentially independent of time, at least six hours were necessary to

completely form the penta-o-trimethylsilyl derivatives of fructose. The penta-o-trimethylsilyl derivatives of glucose were formed within five minutes as indicated in the literature.

Anomerization from alpha- to beta-fructose occurred after the introduction of the TMS reactants. This was not in agreement with the literature.

During curing and storage the reducing sugars glucose and fructose increased in Centennial and Goldrush roots and remained relatively unchanged in Acadian and Julian roots. During baking, all varieties increased in glucose and fructose. Maltose was not present in raw roots; however, after baking it was the sugar in most abundance.

The sucrose content of the four varieties increased significantly during curing and storage for 4.5 months. During baking, the sucrose content of Centennial, Goldrush and Julian roots decreased significantly.

Acadian roots contained significantly more inositol than the other varieties used in this study.

During curing, storage and baking, a highly significant positive correlation existed between glucose and fructose. A significant negative correlation existed between glucose and inositol. The relation between sucrose and inositol was significant and positive.

After baking, a highly significant positive correlation existed between maltose and sucrose.

INTRODUCTION

The sweet potato (Ipomoea batatas, Poir.) is considered one of the most important vegetable crops throughout the tropical and subtropical areas of the world. Sweet potato varieties grown for eating purposes are divided into the "yam" or "moist-fleshed", and the "Jersey" or "dry-fleshed" types. The yam type, which is grown commercially in the southern part of the United States, has the property of becoming soft and syrupy when baked. Conversely, the Jersey type remains relatively firm and dry when baked.

Since the sweet potato is a warm season crop, it must be stored or preserved in some manner if it is to be consumed during the entire year. It is understandable then that much experimental work has been done on determining the best conditions of curing, storing and baking the roots.

The carbohydrate transformations occurring in the sweet potato have been studied extensively in relation to different temperatures and lengths of curing and storage. These transformations, however, have received little attention on an individual basis. For the most part, investigations have dealt with starch, total sugar and occasionally reducing and non-reducing sugars. Lambou (24)

has been the only investigator to follow changes in individual sugars and the polyhydroxy alcohol inositol.

However, the extraction method used by him, in reporting maltose in the raw roots, is somewhat questionable. No study has dealt with the individual sugars and inositol as affected by baking the roots.

For these reasons, it was thought that carbohydrate extraction methods warranted further study as well as a recently published determination for polyhydroxy compounds by Sweeley et al. (38).

It was decided to use four varieties in this work, Acadian, Centennial, Goldrush and Julian, in order to ascertain carbohydrate behavior in normal curing, storage and baking conditions in these varieties. In this way it is hoped that a better understanding of some of the quality attributes of sweet potatoes can be developed.

REVIEW OF LITERATURE

The importance of curing and storage temperatures and relative humidities is essential to both the production and the utilization of the sweet potato. Most workers agree that curing for proper wound healing should be effected immediately after harvest. Curing at a temperature of 85 to 90° F and a relative humidity of 85 to 90 per cent for five to ten days has been found to be the most effective (23, 26, 33).

After curing, physiological and pathological disorders are minimized when sweet potatoes are held at 55 to 60° F and a relative humidity of 80 to 90 per cent (8, 26, 33). Kimbrough and Bell (22) found that chilling injury resulted if the temperature of storage was below 50° F. Cooley et al. (8) stored cured sweet potatoes at 50, 55 and 60° F. At the end of three months of storage, there were no differences in the percentages of sound potatoes. However, at the end of five months of storage, the percentage of sound potatoes of all variety averages at 50° F was significantly less than at 55 or 60° F.

Carbohydrate Content as Affected by Curing and Storage

Total Sugars. Concerning the effect of curing and

storage conditions on the sugar constituents of sweet potatoes, Harrington (14), in 1895, observed an increase in the sugar content throughout storage. Several investigators found the total sugars to increase as a result of the curing process (13, 35, 41). Lambou (24) working with the Unit I Porto Rico variety found the sugars, expressed as per cent of total solids, to increase from 18.96 per cent to 19.43 per cent as a result of the curing process. He further observed an increase in sugars to 26.56 per cent following storage at 60° F for six months. Cadiz (7) found the total sugars to increase after a 14 day curing period. It was also observed that total sugars increased in all whole roots and all portions of roots (proximal, center, and distal) throughout a six month storage period. It was further noted that no differences existed in the total sugar contents due to root size.

McCombs and Pope (28) followed the sugar content of sweet potatoes held, after curing, in storage at 55, 60 and 65° F. They found the greatest amount of sugar present in the roots held at the lower storage temperature. Sistrunk et al. (37) in a similar experiment used 50 and 60° F and common storage temperatures and found the greatest accumulation of total sugars in the potatoes kept at 50° F. Arthur and McLemore (3) also found a greater increase in sugar content in roots kept at 50° F compared to those in 60 or 70° F storage. However, as indicated earlier, sweet

potatoes are susceptible to chilling injury below 55° F (8, 22, 23).

Gaafar (11) found a greater accumulation of sugars in roots stored at 55° F, and Omar (32) observed a greater accumulation of sugars at 60° F. These were the lowest storage temperatures in their respective studies.

Hernandez (17) reported that a highly significant negative correlation existed between the specific gravity and total sugars in sweet potatoes and a highly significant positive correlation between specific gravity and percentage of starch. Specific gravity determinations were made following curing the roots for ten days at 85° F and storage for six weeks at 60° F. The specific gravity in all varieties was highest immediately after harvest and lowest after six weeks of storage (17). This indicated that the accumulation of total sugars in the roots occurred following curing and storage. Bryant (6) also found that low specific gravity sweet potato roots contained a higher percentage of sugar and a lower percentage of starch.

Reducing and Non-Reducing Sugar. Thompson and Whittier (40) in 1912 were among the earliest investigators to define the forms of sugar occurring in fruits and vegetables. They found 2.40 per cent sucrose, 0.48 per cent fructose and 1.23 per cent glucose (fresh weight basis) in the Gold Skin variety of sweet potato. Miyake (29) in 1915 confirmed these results and discounted the presence of pentoses, galactose,

mannose and maltose.

One of the first complete accounts of carbohydrate transformations in Irish potatoes and other subterranean organs was made by Muller-Thurgau as cited by Hasselbring and Hawkins (16). Muller-Thurgau found that an accumulation of sugar and a corresponding loss of starch occurred in potatoes kept at low temperatures (0 to 6° C). He also showed that the sugar formed is mostly reducing sugar with some sucrose present in the proportion of 2.5 to 1.0 respectively (16).

Hasselbring and Hawkins (16), working with sweet potatoes, found that, immediately after harvest, there was a rapid transformation of starch into sucrose and reducing sugars. They concluded that this transformation seemed to be due to internal causes and was largely independent of external conditions. Even at a temperature of 30° C both sucrose and reducing sugars initially accumulated in excess of the quantity used in respiration (16). Hasselbring and Hawkins (16) also reported that changes in concentrations in reducing sugars were less marked than those in sucrose. Shiver (36) concluded that the amount of starch lost was generally equivalent to the amount of sucrose gained. In the case of glucose, there was no appreciable change (36).

In a later publication Hasselbring and Hawkins (15) investigated the initial carbohydrate transformations following harvest of sweet potatoes. They concluded that

starch was first converted to reducing sugar and that sucrose was synthesized from the reducing sugar. The rates of starch hydrolysis and of sugar synthesis conformed in a general way to the Van't Hoff temperature rule for rates of chemical reactions (15).

In contrast to the ratio of 2.5 to 1.0 of reducing sugar to sucrose in the Irish potato, Hasselbring and Hawkins (16) found a ratio of 1.0 to 4.0-5.0 of these sugars in sweet potatoes. The sweet potato sugar ratio was obtained from two varieties held both in cold and warm storage.

Hopkins and Phillips (18) studied the effects of 50, 55, 60, 65 and 70° F storage temperatures on both cured and uncured sweet potatoes. Reducing sugars were found to be low initially (0.2 to 0.4 per cent fresh weight) and remained constant throughout the storage period at all of the storage temperatures. The sucrose content in the samples to be cured was 2.5 per cent in the freshly harvested sweet potatoes and increased to 3.3 per cent during the curing period. Storage temperatures of 50 and 55° F were conducive to an increase in sucrose while storage temperatures of 60, 65 and 70° F caused a decrease in the sucrose levels. In the uncured samples, sucrose followed the same trend as in the cured samples in 50° and 55° F storages. In 60, 65 and 70° F storage temperatures, there was at first an increase in sucrose, reaching maxima at about 20, 12 and 10 days respectively, followed by decreases (18).

Blackwell and Scott (5), in a similar study, cured sweet potatoes and transferred them to storage temperatures of 48, 55, 62, 69, 76 and 83° F. They noted slight increases in the reducing sugar content of the roots stored at 48 and 55° F followed by slight decreases. In roots stored at the higher temperatures there was a marked reduction of the per cent reducing sugar. Hammett and Barrentine (13) found reducing sugars in sweet potatoes to increase significantly during curing and storage at 55 to 60° F. Ali (1) observed increases in reducing and non-reducing sugars in roots held at 60° F storage following curing. The data of Jenkins and Anderson (19) are similar to those of Ali (1) in that both reducing and non-reducing sugars increased in the roots kept at 55 to 60° F. Reducing sugar was found to increase constantly following normal curing in potatoes held at common and 60° F storage (32). However, Omar (32) found non-reducing sugars in sweet potatoes to increase to the fourth month of storage, after which there was a slight decrease. Cadiz (7) found the reducing sugar content of samples in 60° F storage to remain fairly constant while slight reductions occurred in roots stored in common storage. The non-reducing sugars increased regardless of storage temperature (7). Morris and Mann (30) found reducing sugars to increase in sweet potatoes during storage at 60 to 70° F. Sistrunk et al. (37) reported an increase in the reducing sugar content of three sweet potato

varieties held in 60° F storage. The non-reducing sugars increased to the second month of storage and then decreased in two of the three varieties (37). Barham and Wagoner (4) reported that under normal curing condition, non-reducing sugars increased regularly to the sixteenth week in storage. Reducing sugars increased to the fourth week after which they decreased continually to the sixteenth week.

Lambou (24) was the first investigator to study the individual components of reducing sugars (glucose, fructose and maltose) in the sweet potato as affected by storage. After normal curing, the quantities of sucrose, glucose and fructose were higher, especially the reducing sugars. By the end of the first month of storage, however, there was considerably less of the three sugars than had been found in the freshly harvested potatoes. This was followed by significant increases in both glucose and fructose at the end of six months of storage at 60° F. Sucrose increased during this same period, but the increase was not significant.

A search of the literature has shown Lambou (24) to be the only investigator to report the presence of the reducing sugar maltose in raw sweet potato roots. The concentration was small and relatively constant. Maltose occurred in an approximate ratio of 1.0 part maltose to 4.6 parts of other reducing sugars (glucose plus fructose) throughout normal curing and four months of storage.

Inositol. Lambou (24) reported changes in the concentrations of inositol as affected by curing and storage of raw roots. Inositol increased from a trace at harvest time to a maximum after one month of storage at which time its concentration was greater than that of either glucose or fructose. From this point in storage, inositol decreased to the sixth month of storage. Angyal and Anderson (2) reported that inositol can be synthesized from D-glucose; however, a cyclase has not been isolated from sweet potatoes.

Carbohydrate Content as Affected by Baking

Numerous studies have been conducted to determine the effect of the baking process on the carbohydrate content of sweet potato roots. Hammett and Barrentine (13) showed baking to increase total sugars from 3.27 to 12.32 per cent in cured and stored roots of Allgold, and from 2.28 to 18.21 per cent in Porto Rico potatoes. This amounted to a four-fold increase in Allgold and an eight-fold increase in Porto Rico roots. The reducing sugars in these same roots increased from 0.18 to 4.81 per cent in Allgold and from 0.54 to 7.83 per cent in Porto Rico sweet potatoes. Ali (1), working with two varieties which had been cured and stored, showed that both varieties increased significantly in dry matter, total sugar and reducing sugars during baking. The total sugar increased from 5.14 to 11.62 per cent in Acadian and from 4.28 to 10.83 per cent in Earlyport sweet

potatoes as a result of baking. Reducing sugars in these roots increased from 0.31 to 6.73 per cent in Acadian and from 0.98 to 7.22 per cent in Earlyport. These data indicate a twenty-one-fold increase in Acadian and a seven-fold increase in Earlyport roots. Similar increases in reducing and total sugars were also observed by Culpepper and Magoon (9), Gore (12) and Jenkins and Gieger (21).

The presence of large amounts of maltose in cooked sweet potatoes has been demonstrated by several investigators (9, 12, 20, 24). Gore (12) found the percentage of maltose in the Nancy Hall variety to increase to 13 per cent on a fresh weight basis as a result of baking. A 7 to 14 per cent increase occurred, depending upon variety, according to Culpepper and Magoon (9). Jenkins and Gieger (20) found Porto Rico and Allgold to contain about ten per cent and two per cent maltose respectively after the baking process. As a result of dehydration, Lambou (24) found maltose to be the sugar of most abundance in the sweet potato.

Most workers have found little change in the non-reducing sugar content of sweet potatoes during cooking (1, 9, 12, 37). However, Jenkins and Gieger (20) found that baking tended to decrease the amount of non-reducing sugars present, and there appeared to be no differences among varieties in this respect.

Sistrunk et al. (37) showed that the per cent total

solids in the fresh root apparently influenced the level of total sugars during baking, since there was not much moisture loss during baking. Heartogold, having low total solids, accumulated less total sugars on a fresh weight basis than did Unit I Porto Rico, which possesses high total solids. However, on a dry weight basis, Heartogold accumulated more total sugars than did Unit I Porto Rico.

MATERIALS AND METHODS

Four varieties of sweet potatoes, Acadian, Centennial, Goldrush and Julian were used in the experiments of this study. Three replications of each of the above varieties were grown at the Sweet Potato Research Center at Chase, Louisiana. After harvest, the roots were transported to Baton Rouge where samples were drawn for determinations at harvest time. The remainder of the roots was cured for ten days at 85° F and a relative humidity of about 85 per cent, and then stored at 60° F and a relative humidity of about 70 per cent.

Carbohydrate and dry matter analyses were determined at harvest time, after five days of curing, after ten days of curing and after storage for 6, 12, 18 and 24 weeks. In addition, these determinations were made on baked roots after having been cured and stored for 24 weeks.

For the baking tests a natural gas oven was used. The sweet potatoes were baked for 75 minutes at a temperature of 375° F. After baking, the roots were left to cool for 30 minutes at room temperature before sampling. By using these conditions, Ali (1) found better culinary quality in the baked products.

Extraction. The extraction of sweet potato sugars was

performed essentially by the method of Nettles (31) and of Folch et al. (10) with some modification, as diagrammed in Figure 1.

Approximately a 1.5 gram composite sample from the twelve roots comprising a replication was obtained with a number one cork borer. The sample was immediately weighed and homogenized in 30 ml of chloroform-methanol (2:1) for one minute at top speed in a Virtis 45 homogenizer. An internal standard of exactly 0.01 gram of alpha-methyl-D-mannoside was combined with the sample prior to homogenization (34).

After standing overnight, the homogenate was centrifuged for 10 minutes at a relative centrifugal force (RCF) of 10,000 X g . The supernatant was decanted into a separatory funnel and was partitioned by the addition of a 0.2 volume of water. After the funnels were shaken and allowed to stand overnight, the lower layer containing the lipids was drawn off and the upper layer containing the sugars was saved.

The precipitate remaining after the chloroform-methanol extraction was extracted twice with 30 ml of 80 per cent ethanol. After each addition of ethanol, the centrifuge tubes were allowed to stand overnight before centrifugation at an RCF of 10,000 X g for 10 minutes. These supernatants were combined with the upper layer of the chloroform-ethanol extraction. The combined extracts

Figure 1. Chloroform-Methanol Extraction and Trimethylsilylation of Sweet Potato Sugars and Inositol.

Homogenized tissue with 2:1 (v/v) chloroform-methanol

Stood overnight at room temp. Centrifuged 10,000 X g, 10 min.

Precipitate

Supernatant

Extracted twice with 80% ethanol. Allowed to stand overnight at room temp. and centrifuged at 10,000 X g, 10 min. after each extraction.

Partitioned with 0.2 vols. water and stood overnight at room temperature.

Lower layer

Upper layer

Precipitate

Supernatant

Combined

Evaporated under reduced pressure at 30° C. Redissolved in 5.0 ml water. 0.5 ml aliquot evaporated to dryness in a desiccator in vacuo.

Sugars and Inositol

Added anhydrous pyridine, hexamethyldisilazane, and trimethylchlorosilane (10:2:1).

Gas-liquid chromatography (GLC)

were taken to dryness using a Buckler Rotary Evapo-Mix at 30° C. The sugar extract was then suspended in 5.0 ml of distilled water and an aliquot of 0.5 ml was placed in a one dram plastic stoppered vial. The vial was taken to dryness in vacuo in a desiccator.

Sugars were determined quantitatively with gas-liquid chromatography by the method of Sweeley et al. (38). The dried sugars were trimethylsilylated (TMS) with 1.0 ml anhydrous pyridine (kept over KOH pellets), 0.2 ml hexamethyldisilazane and 0.1 ml trimethylchlorosilane (10:2:1). After the addition of the TMS reagents, the vial was stoppered and shaken vigorously for two minutes. The vial was left to stand at room temperature for at least nine hours, but not more than 20 hours, to completely form derivatives before separation by gas-liquid chromatography.

The TMS derivatives of sugars were separated by use of a Micro-Tek 2500 R gas chromatograph equipped with a dual flame ionization detector. Dual, six foot long, one-eighth inch o. d. diameter, stainless steel columns, packed with 3.0 per cent silicone gum rubber (SE-52) on acid washed, DMCS treated, high purity 80-100 mesh chromosorb W were used. The column temperature was programmed to increase at 5° C per minute from 110 to 250° C. Inlet and ion detector temperatures were maintained at 275 and 300° C respectively. Helium supplied at 60 cc per minute served as a carrier gas. Hydrogen at a flow rate of 60 cc per minute serviced the

dual hydrogen flame. Compressed air supplied at the rate of 1.2 cubic feet per hour served as the scavenger gas. A 0.8 μ l sample of the TMS derivatives was injected into the gas chromatograph for separation.

Identification of sugar and inositol TMS derivatives was accomplished by comparison of relative retention ratios of unknowns with those of authenticated standards. Quantification of the sugars and inositol was performed with the use of standard curves. Varying amounts of individual sugars and inositol with constant amounts of internal standard (α -methyl-D-mannoside) were first mutarotated in water for 24 hours at 45^o F. The standards were dried in vacuo in a desiccator, subjected to the TMS reagents and chromatographed. By plotting the ratio of front side peak heights of the separated anomers of each sugar and inositol to that of the standard against the weight of sugar or inositol, linear calibration curves were obtained (34, 43). The weights of the individual sugars and inositol were obtained from the following equations of the calibration curves:

$$\text{glucose} = \frac{y - 0.0385}{192.3}$$

$$\text{fructose} = \frac{y + 0.0250}{233.3}$$

$$\text{maltose} = \frac{y + 0.0425}{70.0}$$

$$\text{sucrose} = y$$

$$\text{inositol} = \frac{y - 0.0330}{227.3}$$

where y was equal to the ratio of sugar or inositol to that of the internal standard.

Mutarotated glucose and fructose, when chromatographed on the SE-52 column, revealed satisfactory separation of beta-fructose and beta-glucose. However, alpha-fructose and alpha-glucose were retained as a composite peak. To estimate the quantities of these two anomers, the following equations were used:

$$\text{alpha-fructose} = 0.032 \times \text{beta-fructose}$$

$$\text{alpha-glucose} = (\text{alpha-fructose} + \text{alpha-glucose}) - (\text{alpha-fructose})$$

The total peak heights for each sugar were then obtained by summation of peak heights of existing anomers.

Comparisons between the modified methods of Nettles (31) and Folch et al. (10), and the method of Magoon and Culpepper (27) for sugar extractions were made. For comparison, triplicate samples from twelve roots of the Centennial variety were subjected to extraction by the two methods. An additional test consisted of triplicate extractions by each method of 0.01 gram alpha-methyl-D-mannoside plus 0.01 gram authentic glucose. The per cent recovery of glucose by each method was calculated by the following equations (34):

Weight of Unknown =

$$\frac{\text{Weight of Internal Standard} \times \text{Peak Area of Unknown}}{K \times \text{Peak Area of Internal Standard}}$$

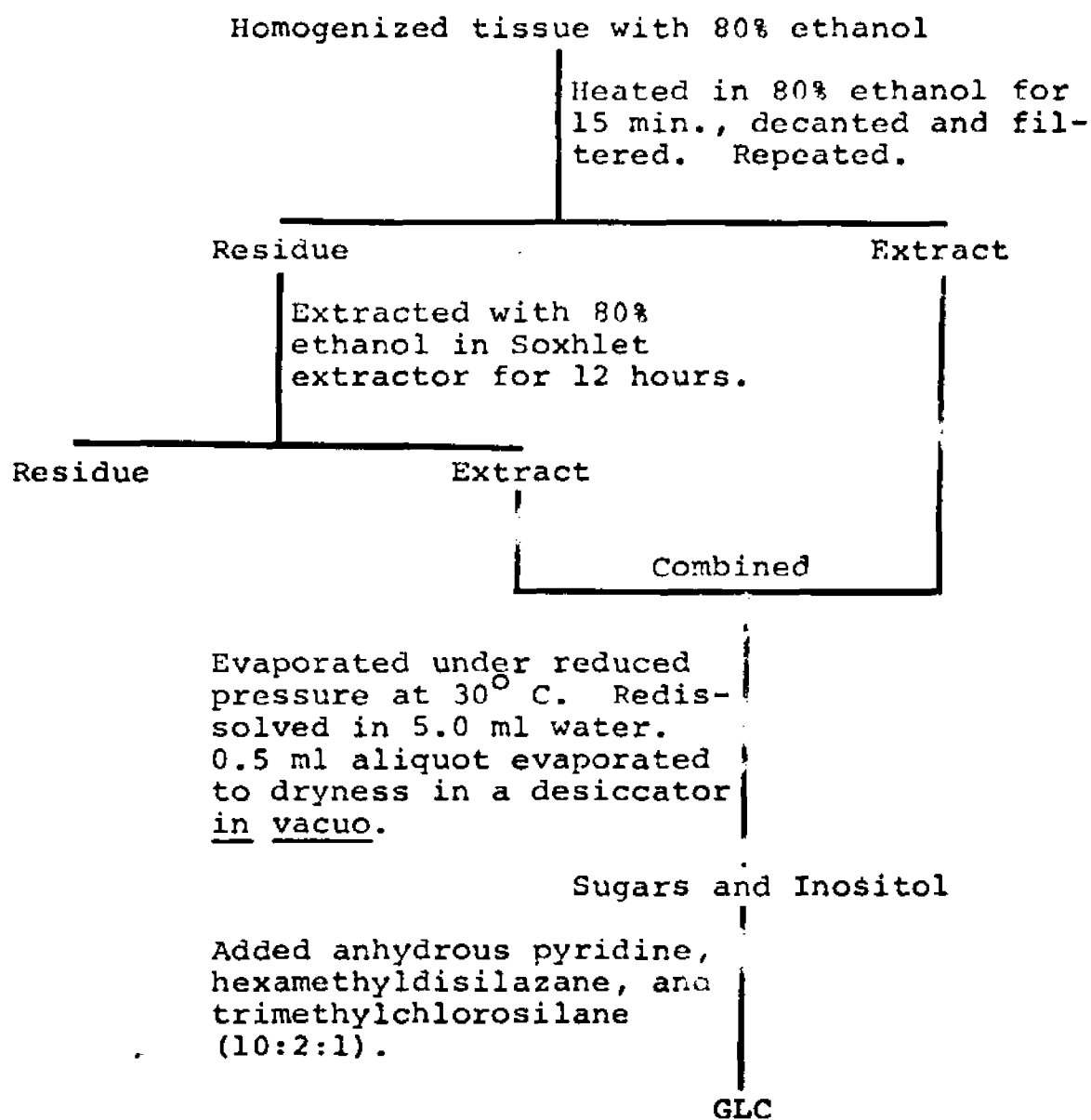
K =

$$\frac{\text{Total Area for Sugar/Peak Area of Internal Standard}}{\text{Weight of Sugar/Weight of Internal Standard}}$$

In the Magoon and Culpepper extraction (27), a composite 1.5 gram sample and internal standard were obtained and homogenized as in the modified Nettles (31) and Folch et al. (10) methods. In this case, homogenization was accomplished with 30 ml of 80 per cent ethanol. The homogenate was heated in a beaker at 96° C for 15 minutes after which the liquor was decanted into a paper extraction thimble. After an additional extraction of the residue with 30 ml of 80 per cent ethanol, the residue and extract were quantitatively transferred to the extraction thimble. The liquor was allowed to filter through the thimble and was saved. The thimble was placed in a Soxhlet apparatus and extracted with 80 per cent ethanol for 12 hours. Extracts were combined and taken to dryness using a Buckler Rotary Evapo-Mix at 30° C. The extracts were suspended in water and an aliquot was taken to dryness as in the modified methods of Nettles (31) and Folch et al. (10). TMS derivatives were made and subjected to gas-liquid chromatography (38). The extraction procedure used is outlined in Figure 2.

A study was undertaken to ascertain the effect of time on the quantity of the TMS product formed. Test sugars consisted of authentic alpha-D-glucose and beta-D-fructose.

Figure 2. Ethanol Extraction and Trimethylsilylation of Sweet Potato Sugars and Inositol.



An accurately weighed 0.01 gram sample was placed in an aluminum foil wrapped one dram plastic stoppered vial. The usual reaction mixture was carefully pipetted into the vial. The mixture was shaken vigorously for 30 seconds according to Sweeley et al. (38) and then was placed in a constant temperature water bath at 21.5° C. Accurately measured 0.4 μ l aliquots, drawn into a 2- μ l series "A" Precision Sampling syringe, were injected into the chromatograph after 0.12, 0.25, 0.50, 1, 2, 3, 4, 5, 6, 7, 8, 10, 12 and 24 hours. Observed areas were measured by triangulation. Each sugar was run in triplicate.

The effect of deionization on quantitative changes in sugars and inositol after the chloroform-methanol extraction was studied. For testing, triplicate samples from twelve roots of the Centennial variety were extracted as previously outlined by the chloroform-methanol method. An additional test consisted of triplicate extractions of 0.01 gram alpha-methyl-D-mannoside plus 0.01 gram authentic glucose. The per cent recovery of glucose as affected by deionization was calculated by the equations of Sawardeker and Sloneker (34).

After redissolving the dried samples in 5.0 ml of water, a 1.0 ml aliquot was deionized, and a 0.5 ml aliquot was taken to dryness in a desiccator as previously described. A small chromatographic tube with a bed volume of 6.5 gram layered MB-3 resin obtained from Mallinckrodt Chemical Works

was used for deionization. The 1.0 ml aliquot was placed on top of the "wet" column. A wash bottle containing distilled water was used to add 2-3 ml of water three times, as the effluent eluted from the column. The column was then filled to the top (20 ml) and eluted. Finally, 10 ml of water were added and eluted. The total effluent collected was taken to dryness using a Buckler Rotary Evapo-Mix at 30° C. The sugar extract was then suspended in 1.0 ml of distilled water and a 0.5 ml aliquot was taken to dryness in vacuo in a desiccator, and determined by gas-liquid chromatography as previously described.

Varietal glucose, fructose, sucrose, maltose, inositol and total reducing sugars as related to storage treatment and baking effects were subjected to analysis of variance techniques and simple correlation as an aid in interpreting the repeatability of results and in drawing conclusions from the data. All statistical analyses were made according to the procedures described by LeClerc et al. (25).

RESULTS AND DISCUSSION

Comparisons Between Extraction Methods

The comparison between the ethanol extraction method (27) and the modified method of Nettles (31) and Folch et al. (10) on sugars and inositol extracted from Centennial sweet potatoes is shown in Table I. The ethanol extraction method, used by Lambou (24), yielded similar concentrations of sugars and inositol except in the case of maltose. There were no detectable amounts of maltose from the chloroform-methanol extraction, whereas, maltose was present as 2.49 per cent of fresh weight in the ethanol extraction. The amount of maltose found was similar to what Lambou (24) reported. Lambou (24), who has been the only investigator to report the presence of maltose in raw roots, suggested that maltose may have been formed during extraction because of heat. The evidence of this study indicated that this may have been the case, as no maltose was formed in the chloroform-methanol extraction effected at room temperature.

A 100 per cent recovery of glucose was obtained by both the ethanol and the chloroform-methanol extraction methods.

Table I. Comparison of methods for extraction of sugars and inositol from raw Centennial sweet potato roots.

Carbohydrates ¹	Method	
	Ethanol ²	Chloroform-Methanol ²
Glucose	0.33	0.33
Fructose	0.16	0.15
Reducing Sugars	2.98	0.48
Sucrose	3.54	3.47
Maltose	2.49	0.00
Inositol	0.01	0.01

¹Per cent fresh weight basis.

²Average of three samples, two determinations per sample.

Effect of Time on Quantity of TMS Product Formed

After the addition of the TMS reagents to the crystalline forms of glucose and fructose, it was found that the quantity of the penta-o-trimethylsilyl derivative of fructose was dependent on time (Table II). The penta-o-trimethylsilyl derivative of glucose was found to be completely formed within five minutes.

In the case of fructose the quantity of TMS product formed, as determined by total peak area (cm^2), was 4.59 five minutes after reaction with the TMS reagents (Table II). The peak area increased to 5.58 cm^2 seven hours after initial reaction. It then remained relatively unchanged through the remainder of the 24 hour test period at which time peak area was 5.65 cm^2 . This represents a 23 per cent increase in product formed during the test period between five minutes and 24 hours after reaction. The data in this study do not support that of earlier workers. It had been reported by Sweeley et al. (39) and Williams (43) that five minutes and 30 minutes respectively, were sufficient for complete reaction.

Anomerization from alpha- to beta-fructose was found to occur after the introduction of the TMS reactants. It can be seen in Table II that the per cent alpha-fructose decreased from 20.5 per cent five minutes after reaction, to 3.2 per cent after 24 hours. Coinciding with this

Table II. Quantities of penta-o-trimethylsilyl derivatives of fructose formed in relation to time.¹

Time in hours	Per cent beta- fructose	Per cent alpha- fructose	2 Peak area in cm		
			Beta- fructose	Alpha- fructose	Total fructose
0.12	79.5	20.5	3.65	0.94	4.59
0.25	81.6	18.4	3.85	0.87	4.72
0.50	83.8	16.2	3.98	0.77	4.75
1	85.7	14.3	4.20	0.70	4.90
2	91.7	8.3	4.62	0.42	5.04
3	93.1	6.9	4.84	0.36	5.20
4	94.3	5.7	5.16	0.31	5.47
5	95.7	4.3	5.28	0.24	5.52
6	96.2	3.8	5.33	0.21	5.54
7	96.6	3.4	5.39	0.19	5.58
8	96.6	3.4	5.43	0.19	5.62
10	96.6	3.4	5.42	0.19	5.61
12	96.8	3.2	5.45	0.18	5.63
24	96.8	3.2	5.45	0.18	5.65

¹Average of three determinations.

decrease, the per cent beta-fructose increased from 79.5 per cent five minutes after reaction to 96.8 per cent at 24 hours.

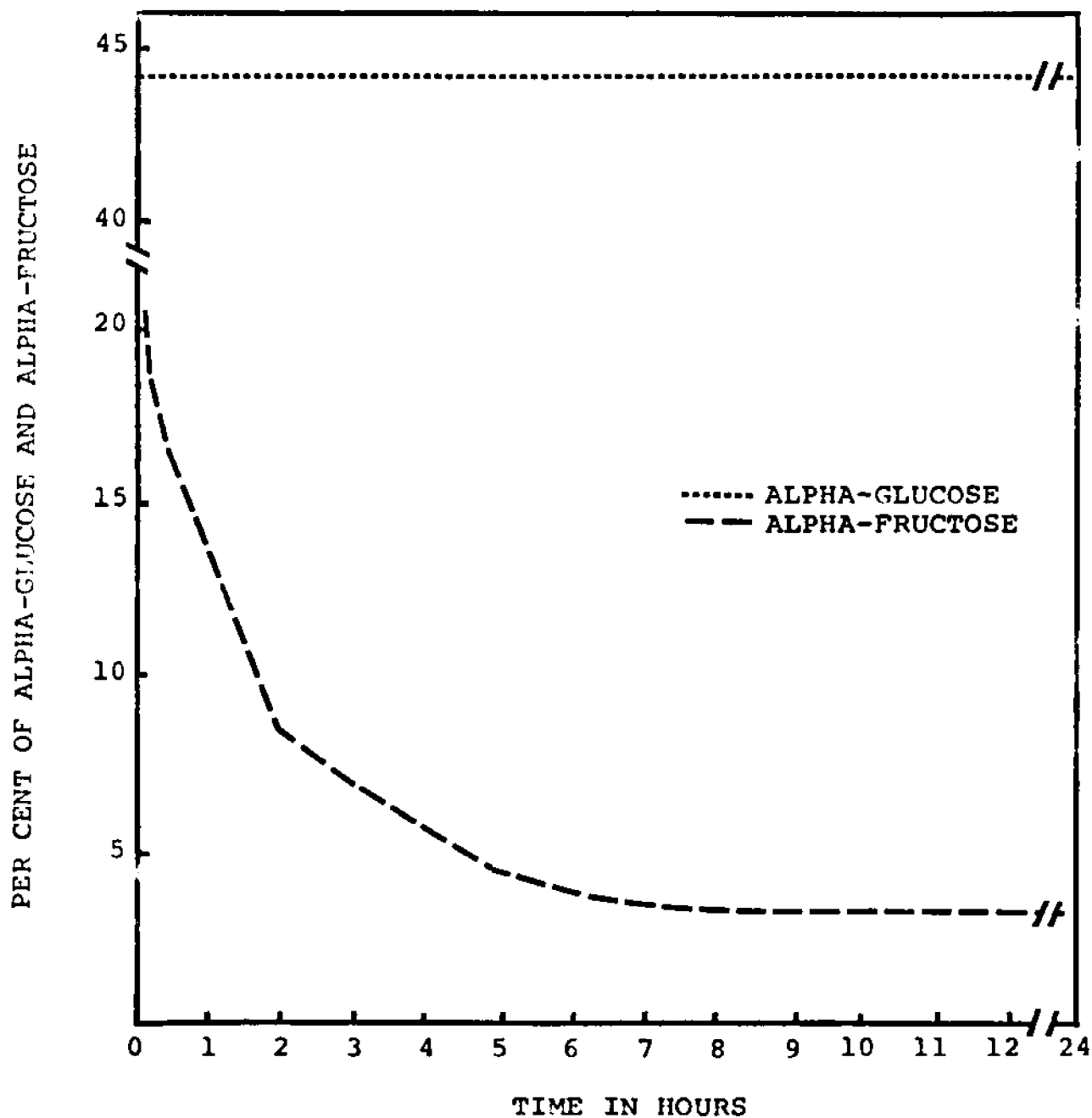
The area under the alpha-fructose peak decreased from 0.94 cm^2 , five minutes after reaction, to 0.18 cm^2 24 hours after reaction. This decrease represented a 0.76 cm^2 loss due to anomerization from alpha- to beta-fructose.

Examination of the increased beta-fructose peak area in Table II showed an increase from 3.65 cm^2 five minutes after reaction to 5.45 cm^2 after 24 hours. An increase of this magnitude (1.80 cm^2) cannot be accounted for entirely by anomerization. The remaining increases (1.04 cm^2) in beta-fructose must be a function of time (Table II).

Glucose was similarly examined for anomerization and quantity of TMS derivatives formed as a function of time. Anomerization did not occur with either alpha- or beta-glucose (Figure 3). Also, there were no additional TMS derivatives formed five minutes after reaction.

The behavior of the penta-o-trimethylsilyl derivatives of glucose supported the findings of Sweeley et al. (38) while the data on fructose derivatives was not in agreement. These authors stated that the quantity of the TMS products formed was essentially independent of time. In addition, they found that anomerizations of the TMS derivatives were remarkably minimal. However, Wiley and Tavakoli (42), working with commercial pectins, allowed their reacted

Figure 3. Relation of time after reaction of TMS derivatives to quantities of alpha peaks of glucose and fructose formed.



mixtures to stand overnight to completely form derivatives.

Effect of Deionization on Sugars and Inositol

Deionization with MB-3 ion exchange resin was found to adversely affect the recovery of sugars and inositol from Centennial sweet potato extracts. Authentic sugars and the alcohol dulcitol were also found by Nettles (31) to be retained in large amounts on the MB-3 ion exchange resin (Table III). Similar quantities of sugars and alcohols were lost as a result of deionization irrespective of the source of the material (sweet potato roots and authentic sugars and dulcitol). A 14.4 per cent recovery of glucose was obtained after deionization, compared to a 100 per cent recovery of the glucose which was not deionized.

In view of the small amounts of sugars and alcohols recovered after deionization, it was concluded that deionization by the method used in this study should be discarded. Since the purpose of deionization is to remove interfering substances, it would appear that the sweet potato root does not contain substances that would warrant their removal. Also, in view of the loss by deionization of pure glucose, the use of MB-3 for deionization of sugar extracts advocated by Sweeley et al. (39) was questioned.

Table III. The effect of deionization with MB-3 ion exchange resin on loss of sugars and alcohols.

Source of material ¹	Per cent loss			
	Glucose	Fructose	Sucrose	Alcohol
Sweet potato	85.1	82.5	49.9	12.3 ³
Authentic sugars ²	80.0	92.4	54.7	10.1 ⁴

¹Average of three determinations.

²Obtained with permission of W. C. Nettles, Jr., unpublished data.

³Inositol.

⁴Dulcitol.

Effect of Curing, Storage and Baking on Sugars and Inositol

Glucose. The effects of variety and the treatments of curing, storage and baking on the glucose content were analyzed by analysis of variance procedures. An interaction between varieties and the treatments occurred, the results of which are presented in Table IV.

Freshly harvested Acadian, Centennial, Goldrush and Julian roots contained low and not significantly different amounts of glucose. After five days of curing, the glucose content of Goldrush roots increased six-fold and was significantly higher than the other varieties. Centennial sweet potatoes, after ten days curing, possessed increased glucose levels which were significantly higher than Acadian and Julian roots. The glucose level of Centennial remained significantly higher than Acadian and Julian and significantly lower than Goldrush roots throughout the curing, storage and baking treatments.

The glucose contents of Centennial and Goldrush roots increased steadily from the date of harvest through three months of storage. There were significantly higher amounts of glucose in both varieties after five days of curing, as compared to freshly harvested roots. Significantly higher glucose levels were observed in both varieties after ten days of curing. At the end of the curing period, the

Table IV. Glucose content (per cent dry weight) of four varieties of sweet potatoes after various curing and storage periods and baking.¹

Variety	Fresh	2		3				Baked
		Cured		Stored				
		5 Days	10 Days	1.5 Mo	3.0 Mo	4.5 Mo	6.0 Mo	
Acadian	0.19	0.21	0.35	0.28	0.25	0.22	0.27	0.64
Centennial	0.12	0.46	0.67	0.67	0.87	1.00	1.07	1.23
Goldrush	0.29	1.77	2.06	2.14	2.51	2.32	2.52	2.87
Julian	0.12	0.13	0.12	0.32	0.31	0.10	0.22	0.57

L.S.D. at 5 per cent level for comparing treatments = 0.20.

L.S.D. at 5 per cent level for comparing varieties = 0.28.

¹Average of three replications.

²Cured at 85° F and 85 per cent relative humidity.

³Stored at 60° F and 70 per cent relative humidity.

⁴Baked at 375° F for 75 minutes.

glucose levels of both varieties continued to increase at a significant level throughout 6.0 months of storage.

The glucose content of Acadian and Julian roots did not significantly differ from each other and remained relatively unchanged throughout curing and storage (Figure 4).

The behavior of the Acadian and Julian varieties with respect to glucose was in agreement with Shiver (36); however, the increased levels of glucose in Centennial and Goldrush were not. Lambou (24) found glucose to significantly increase in Unit I Porto Rico as a result of curing. After one month in 60° F storage, he found that the glucose level significantly decreased. Increased levels of glucose were then reported after four and six months (24). From the observations of these authors and of the present study, it would seem that glucose levels are of a varietal characteristic.

Upon baking, significant increases in the glucose levels occurred in Acadian, Goldrush and Julian varieties. The glucose content of Centennial increased during baking but not significantly.

Fructose. When the data obtained from the treatment effects of curing, storage and baking on the fructose content of the four sweet potato varieties were statistically analyzed, a significant interaction between treatments and varieties resulted (Table V).

At harvest, Acadian contained a significantly higher

Figure 4. The effects of various curing and storage periods and baking on the glucose content of four varieties of sweet potato roots

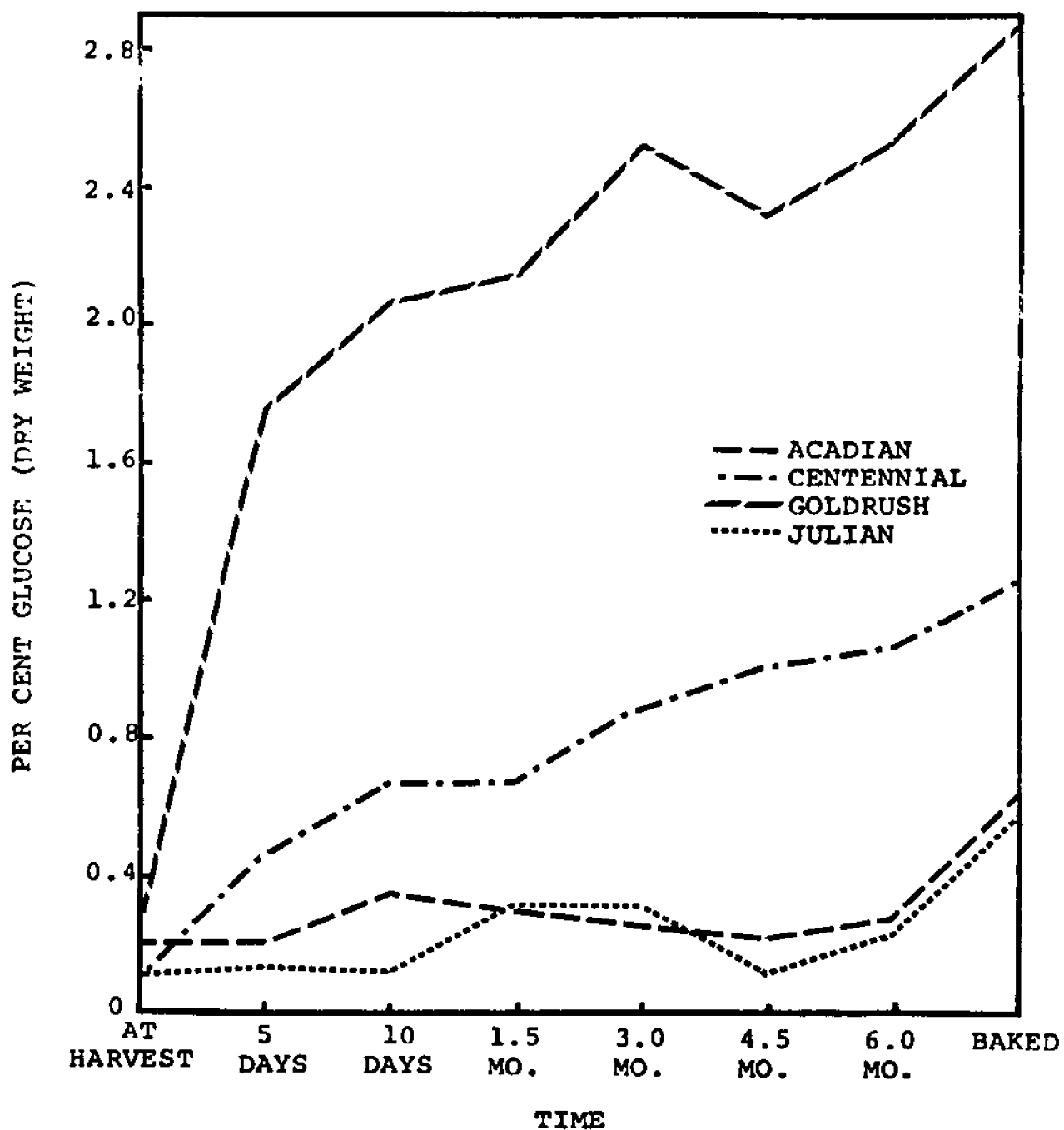


Table V. Fructose content (per cent dry weight) of four varieties of sweet potatoes after various curing and storage periods and baking.¹

Variety	Fresh	2		3				Baked ⁴
		Cured		Stored				
		5 Days	10 Days	1.5 Mo	3.0 Mo	4.5 Mo	6.0 Mo	
Acadian	0.11	0.12	0.13	0.12	0.14	0.19	0.20	0.35
Centennial	0.11	0.21	0.33	0.32	0.44	0.63	0.57	0.68
Goldrush	0.19	1.04	1.01	0.94	1.02	1.11	1.27	1.30
Julian	0.00	0.08	0.06	0.10	0.10	0.11	0.13	0.26
L.S.D. at 5 per cent level for comparing treatments = 0.06.								
L.S.D. at 5 per cent level for comparing varieties = 0.08.								

¹Average of three replications.

²Cured at 85° F and 85 per cent relative humidity.

³Stored at 60° F and 70 per cent relative humidity.

⁴Baked at 375° F for 75 minutes.

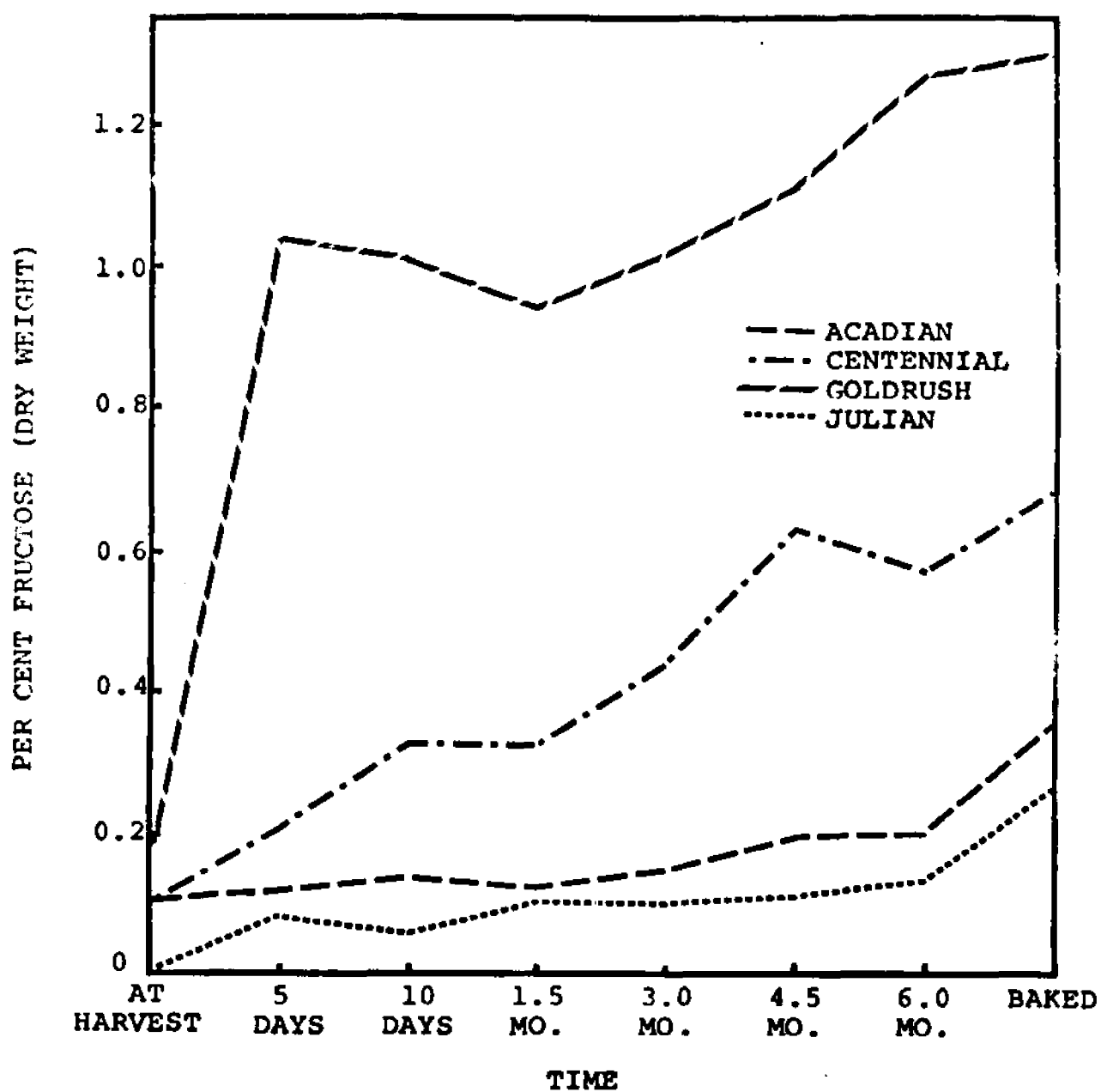
amount of fructose than the Centennial and Goldrush varieties. There were no detectable amounts of fructose in the Julian roots.

After five days of curing, significant increases in fructose were evidenced in the Centennial, Goldrush and Julian varieties. At this period, Goldrush contained significantly higher quantities of fructose than Centennial, which was significantly higher than Acadian and Julian. The varieties retained this relationship with one another from the five day curing period throughout curing and six months of storage. As in the case of glucose, the Goldrush variety accumulated an extraordinarily higher amount of fructose after the five day curing period than the other varieties.

The fructose contents of Acadian and Julian roots showed a tendency to increase after five days of curing through 6.0 months of storage (Figure 5). There was a significant increase in the fructose content of the Centennial variety from five to ten days in curing. During this same period, a slight decrease in Goldrush roots occurred. The significant increases which occurred in Centennial and Goldrush during the ten day curing period parallel the significant increase which Lambou (24) found in Unit I Porto Rico.

As in the case of glucose, the fructose levels of Centennial and Goldrush roots continued to increase at a

Figure 5. The effects of various curing and storage periods and baking on the fructose content of four varieties of sweet potato roots.



significant level throughout 6.0 months of storage. The four varieties in this study were found to roughly approximate the increased fructose concentrations from one to six months in storage found by Lambou (24) in Unit I Porto Rico.

When baked, the roots of the four varieties were found to be significantly different in fructose contents. Baking caused increases in fructose levels of all four varieties, with the increases in Acadian, Centennial and Julian being significant.

As can be seen in Figures 4 and 5, the glucose and fructose levels of the four varieties were found to change similarly with respect to the curing, storage and baking treatments.

Maltose. Even though very low concentrations of maltose could be detected by the method of determination used in this study, maltose was not found to be present in the raw roots. However, after baking the roots the individual sugar in most abundance was maltose. The varieties in this study contained similar amounts of maltose, and no real difference existed between them (Table VI).

Reducing Sugar. At harvest, the reducing sugar contents of the four varieties in this study were similar (Figure 6). As can be seen in Table VII, the reducing sugar contents at harvest were relatively lower compared to their levels after curing. Although there was only a slight increase in reducing sugars in the Acadian and Julian

Table VI. Mean varietal differences in maltose¹ as affected by baking.

Varieties	Mean per cent maltose ²
Acadian	29.96a ³
Centennial	29.77a
Julian	23.60a
Goldrush	22.66a

¹Maltose was only detected and determined in baked roots.

²Expressed on dry weight basis.

³Means not having a letter in common are statistically different at 5 per cent level of significance.

Figure 6. The effects of various curing and storage periods and baking on the reducing sugar content of four varieties of sweet potato roots.

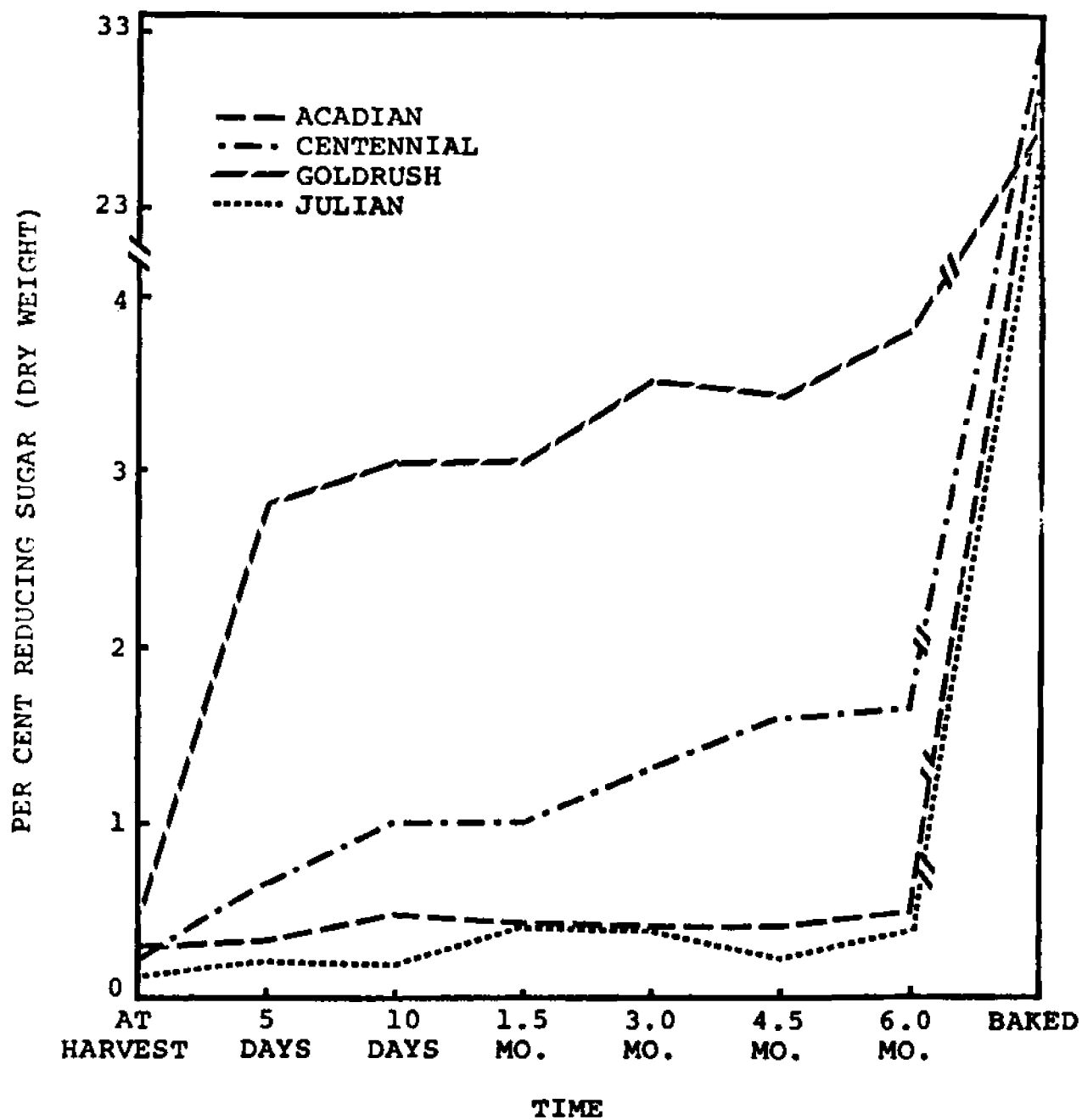


Table VII. Effects of curing, storage and baking treatments on reducing sugars in four varieties of sweet potato roots.

Treatments	Mean per cent reducing sugar ¹
	2
Baking	28.52a
6.0 months storage	1.59 b
4.5 months storage	1.42 b
3.0 months storage	1.41 b
1.5 months storage	1.23 b
10 days curing	1.18 b
5 days curing	1.01 b
At harvest	0.28 b

¹Expressed on dry weight basis.

²Means not having a letter in common are statistically different at 5 per cent level of significance.

roots as a result of curing, the increase, averaged over all varieties, was 3.6 fold higher. This quantitative increase confirms the observations made by previous investigators (13, 15, 16, 24).

In Table VII, it can be seen that when the data are averaged over the four varieties, there was a steady reducing sugar increase through curing and storage. When the reducing sugars were determined 1.5 months after curing, it was found that no increase had occurred in Centennial and Goldrush. By examining Figure 6, it can be seen that more reducing sugar changes took place in these varieties than in Acadian and Julian. There was an increase in Julian roots and a decrease in Acadian roots. It was approximately at this point in storage that Lambou (24) found a significant decrease in reducing sugars in Unit I Porto Rico. Barham and Wagoner (4) found sweet potatoes to contain increasing amounts of reducing sugar up to the fourth week in storage and then to continually decrease to the sixteenth week.

When examined statistically, the continuous increase in reducing sugars from 1.5 months to 6.0 months in storage was found not to be significantly higher. This increase in reducing sugar levels in storage was in agreement with other authors (1, 13, 30, 32, 37). Cadiz (7) and Hopkins and Phillips (18) found reducing sugars to remain constant in storage, while Blackwell and Scott (5) had found decreases in reducing sugars.

Baking was found to cause an average 18 fold increase in the reducing sugar contents of the four sweet potato varieties. This increase was significantly higher than the reducing sugar levels present during curing and storage. Although there were increased levels of glucose (Table IV) and fructose (Table V) as a result of baking, the bulk of the increase was composed of maltose (Table VI).

The increased levels of reducing sugars found in this study as a result of baking support the results of other investigators (1, 9, 12, 13, 21). The demonstration of the presence of large amounts of maltose, which were formed in baking, contributed greatly to the increased reducing sugar, and was in agreement with the work of others (9, 12, 20).

It can be seen in Table VIII that significant differences between varieties were present, with respect to reducing sugars, during curing, storage and baking. Goldrush contained a significantly greater quantity of reducing sugars than Acadian and Julian. Centennial was found to contain more reducing sugars than Julian roots. The Acadian and Julian varieties were found to be not significantly different in amounts of reducing sugars.

Sucrose. When analyzed statistically, the data showing the effects of variety and the treatments of curing, storage and baking on the sucrose content of sweet potato roots resulted in an interaction between varieties and treatments (Table IX).

Table VIII. Mean varietal differences in reducing sugars as affected by curing, storage and baking.

Varieties	Mean per cent reducing sugar ¹
	²
Goldrush	5.89a
Centennial	4.90ab
Acadian	4.22 bc
Julian	3.30 c

¹ Expressed on dry weight basis.

² Means not having a letter in common are statistically different at 5 per cent level of significance.

Table IX. Sucrose content (per cent dry weight) of four varieties of sweet potatoes after various curing and storage periods and baking.¹

Variety	Fresh	2		3				Baked
		Cured		Stored				
		5 Days	10 Days	1.5 Mo	3.0 Mo	4.5 Mo	6.0 Mo	
Acadian	5.26	9.48	10.21	11.83	15.42	18.65	15.63	16.27
Centennial	4.99	6.19	8.24	9.48	10.72	12.56	12.54	11.19
Goldrush	4.91	6.10	7.03	9.48	10.58	12.15	12.30	9.62
Julian	4.88	8.05	8.73	9.27	10.14	11.66	15.68	9.52
L.S.D. at 5 per cent level for comparing treatments = 1.26.								
L.S.D. at 5 per cent level for comparing varieties = 1.79.								

¹ Average of three replications.

² Cured at 85° F and 85 per cent relative humidity.

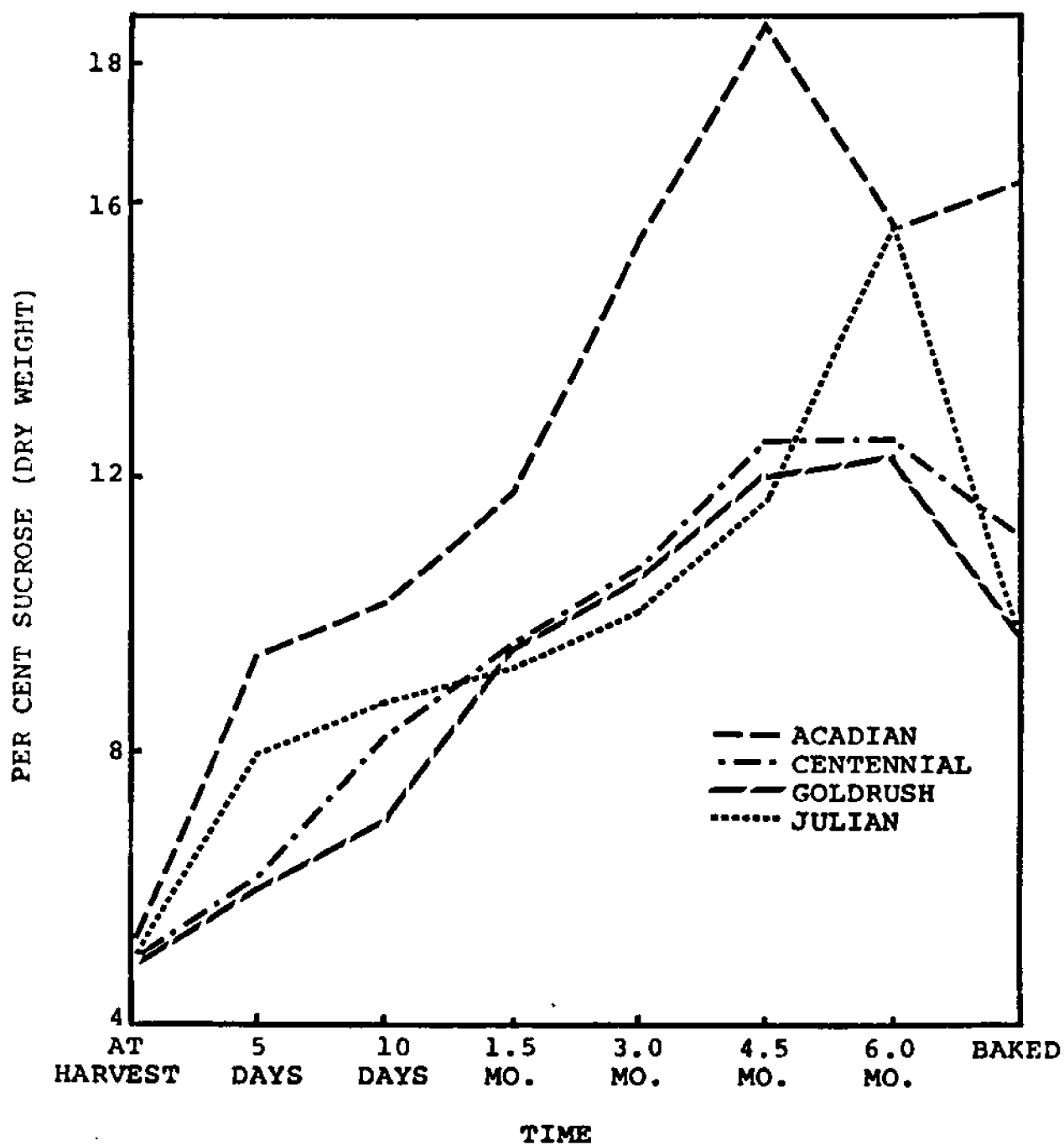
³ Stored at 60° F and 70 per cent relative humidity.

⁴ Baked at 375° F for 75 minutes.

At harvest the sucrose contents of the four varieties were very similar and not significantly different. Five days of curing brought about increases in all four varieties. The increased sucrose levels of Acadian and Julian were significantly higher at this time as compared to freshly harvested roots. Also, at this time the sucrose contents of Acadian and Julian were significantly higher than Centennial and Goldrush roots. The sucrose content of the four varieties continued to increase through ten days of curing. A significant increase in sucrose was observed from the fifth day to the tenth day of curing in Centennial roots. The Goldrush variety showed a significant increase at this time as compared to the freshly harvested roots. In fact, these increases accounted for significant changes in all four varieties as a result of ten days curing. These data were in agreement with the results of Lambou (24) and Hasselbring and Hawkins (15, 16).

As can be seen in Figure 7, the sucrose content of the four varieties in this study increased steadily through 4.5 months of storage. From curing through 4.5 months of storage, Acadian was significantly higher in sucrose content as compared to the other varieties. These continued increases in sucrose are in conflict with the data of Hopkins and Phillips (18) who found storage to cause a decrease in sucrose. However, the data of other investigators support the findings in this study (1, 4, 7, 19).

Figure 7. The effects of various curing and storage periods and baking on the sucrose content of four varieties of sweet potato roots.



From 4.5 to 6.0 months in storage, it was found that the sucrose levels of Centennial and Goldrush remained fairly constant. At the same period in storage, a significant increase in Julian and a significant decrease in Acadian occurred with respect to sucrose contents of the roots. It was also noted that after 6.0 months in storage the sucrose levels of Acadian and Julian were significantly higher than Centennial and Goldrush.

The initial increases occurring in storage shown in these data conflict with the results of Lambou (24), who found significantly less sucrose after one month of storage. Lambou (24) then showed significant increases in Unit I Porto Rico from 1.0 to 6.0 months of storage. Omar (32), whose results opposed those of Lambou (24), found the non-reducing sugar to increase the first month in storage and then to decrease. Sistrunk et al. (37) reported increased non-reducing sugar up to the second month and then decreased amounts during further storage in two of the three varieties in their investigations.

Baking resulted in a slight sucrose increase in Acadian and significant decreases in Centennial, Goldrush and Julian roots. When baked, the Acadian variety was significantly higher in sucrose content than the other varieties. The behavior of the sucrose content in the Acadian variety corresponded to the results of other investigators (1, 9, 12, 37). The decreases exhibited by Centennial, Goldrush

and Julian were in agreement with data by Jenkins and Gieger (20). Thus, it appears that the fate of sucrose during baking is of a varietal nature.

There was a great difference in the ratios of reducing to non-reducing sugars among the varieties in this study. It was found that the relation of reducing to non-reducing sugar in the varieties Julian, Acadian, Centennial and Goldrush occurred after 6.0 months storage in ratios of 1.0 to 37.7, 30.1, 10.3 and 3.9 respectively. After baking, ratios of 1.0 to 33.1, 26.4, 9.1 and 3.5 occurred in the varieties Julian, Acadian, Centennial and Goldrush respectively. The average for all varieties before and after baking resulted in ratios of 1.0 to 20.5 and 1.0 to 18.0 respectively. The decrease in the ratio of reducing to non-reducing sugars as a result of baking was attributed mainly to the increase in maltose. The increases in the reducing sugars glucose and fructose in all varieties and decreases in non-reducing sugars in three of the varieties in baking played a lesser role in reducing the ratio. The ratio of 1.0 to 4.0-5.0 of reducing to non-reducing sugars reported in two varieties by Hasselbring and Hawkins (16) was considerably lower than the ratios found in three of the varieties in this study. This dissimilarity is most likely a varietal trait.

Inositol. Acadian sweet potatoes were found to contain significantly more inositol than the other varieties in this study (Table X). Goldrush roots were found to contain

Table X. Mean varietal differences in inositol as affected by curing, storage and baking.

Varieties	Mean per cent inositol ¹
	²
Acadian	0.12a
Goldrush	0.04 b
Julian	0.03 c
Centennial	0.03 c

¹Expressed on dry weight basis.

²Means not having a letter in common are statistically different at 5 per cent level of significance.

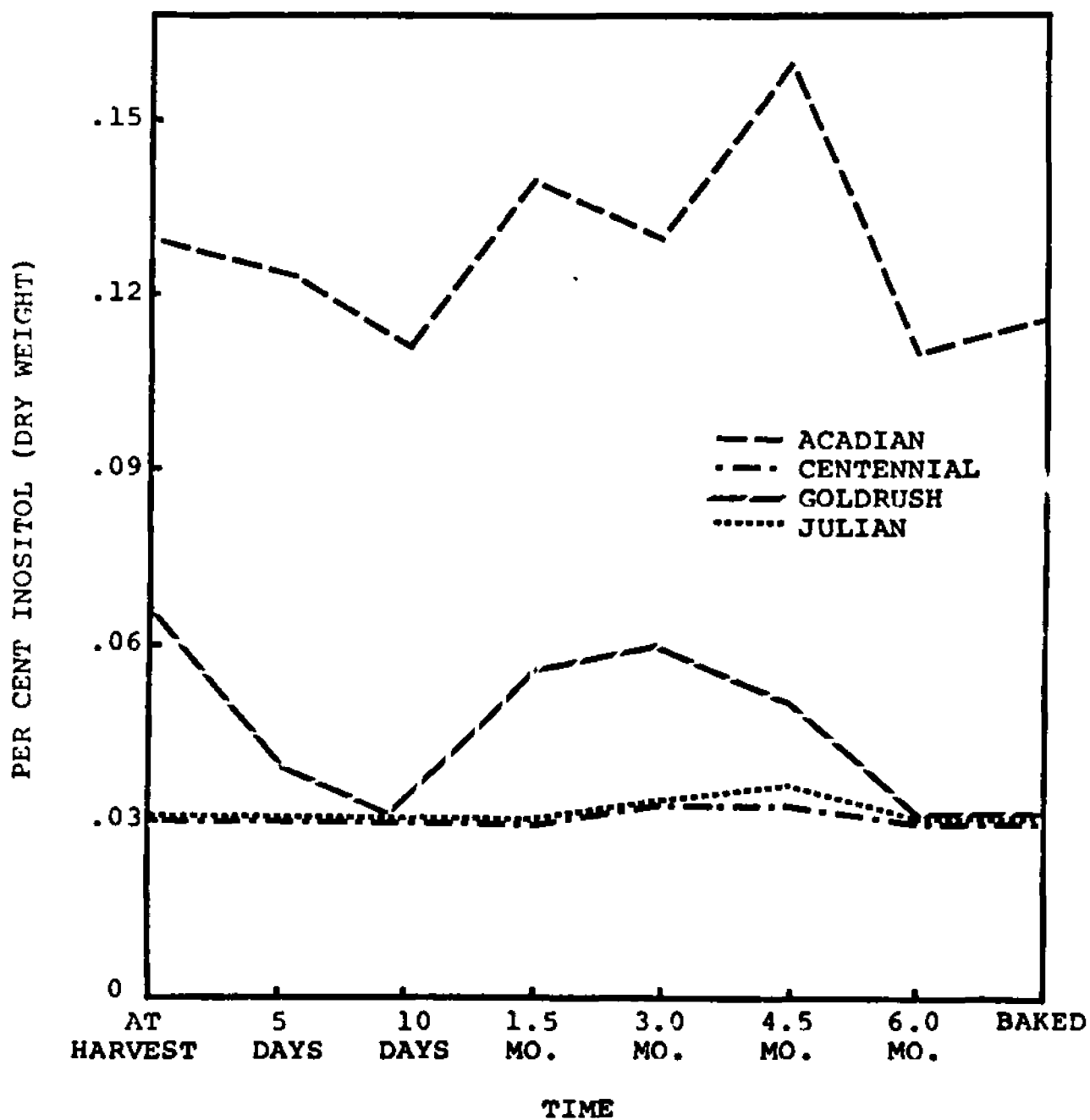
significantly more inositol than Julian and Centennial, which were not significantly different from each other. No real differences were revealed which were due to the curing, storage and baking treatments.

It can be seen in Figure 8 that curing resulted in decreased inositol levels in Acadian and Goldrush roots. Inositol levels in Centennial and Julian remained unchanged throughout the curing period. These data are in conflict with the findings of Lambou (24) who noted increased levels of inositol during curing.

Inositol determinations following 1.5 months of storage revealed increases in Acadian and Goldrush, whereas no change was shown in Centennial and Julian. The increased inositol in Acadian and Goldrush is in agreement with the data of Lambou (24). Increased levels of inositol were exhibited by Centennial, Goldrush and Julian roots in the period of 1.5 to 3.0 months in storage. During this same period, the inositol content of Acadian decreased. The inositol levels of Acadian and Julian roots increased, Centennial remained unchanged, and Goldrush decreased from 3.0 to 4.5 months in storage. Decreased inositol contents of the four varieties were shown during the period of 4.5 to 6.0 months in storage. The results of Lambou (24) regarding the decrease in inositol from 4.0 to 6.0 months in storage are in agreement with the findings of the present study.

Inositol remained unchanged as a result of baking in

Figure 8. The effects of various curing and storage periods and baking on the inositol content of four varieties of sweet potato roots.



Centennial, Goldrush and Julian varieties. The occurrence of a slight increase in inositol was noted in Acadian roots. Based upon the varieties in this study, it appears that baking has little effect upon the inositol level in sweet potato roots.

Relationship Between Sugar and Inositol Changes
During Curing, Storage and Baking

All data collected after curing, storage and baking were subjected to simple correlation analysis. The coefficients are presented in Table XI.

Glucose and fructose were positively correlated with reducing sugar at the .01 level of significance. This was to be expected as the reducing sugar values were contributed to by both glucose and fructose.

A highly significant positive correlation existed between glucose and fructose. As both of these sugars are hydrolytic products of sucrose, it is possible that their presence in relatively the same ratios can be attributed to their utilization in metabolizing sucrose. Hasselbring and Hawkins (15) have suggested that starch is first converted to reducing sugars and sucrose is synthesized from reducing sugars.

Glucose was negatively correlated with inositol at the .05 level of significance. This relationship may indicate that inositol was synthesized from glucose. Angyal and

Table XI. Simple correlation coefficients among sugar and inositol changes during curing, storage and baking.

Glucose X Fructose	.9735**
Glucose X Reducing sugar	.3117**
Glucose X Sucrose	-.0154
Glucose X Inositol	-.2638*
Fructose X Reducing sugar	.3214**
Fructose X Sucrose	-.0173
Fructose X Inositol	-.0141
Reducing sugar X Sucrose	.1749
Reducing sugar X Inositol	-.0424
Sucrose X Inositol	.2347*

**Significant at 1 per cent level.

*Significant at 5 per cent level.

Anderson (2) have reported that inositol can be synthesized from D-glucose; however, a cyclase, which is essential in this conversion, has not been isolated from sweet potatoes.

The coefficient of correlation between sucrose and inositol was positive and significant. The explanation of this relationship could only be accomplished by speculation.

Relationship Between Maltose, Other Sugars
and Inositol After Baking

Since maltose was detected in the roots only after baking them, correlation coefficients between this attribute and the other sugars and inositol were calculated after baking. The coefficients are presented in Table XII.

Maltose was positively correlated at the .01 level of significance with reducing sugar. This relationship is to be expected because the reducing sugars present after the roots were baked were comprised mainly of maltose. This is illustrated by comparing Tables IV, V, and VI.

A highly significant positive correlation existed between maltose and sucrose. This relationship, of corresponding quantities of maltose and sucrose is possibly a varietal trait.

Table XII. Simple correlation coefficients among maltose, other sugars and inositol after baking.

Maltose X Glucose	-.3798
Maltose X Fructose	-.3008
Maltose X Reducing sugar	.9614**
Maltose X Sucrose	.7492**
Maltose X Inositol	.4085

**Significant at 1 per cent level.

SUMMARY AND CONCLUSIONS

Four varieties of sweet potatoes, Acadian, Centennial, Goldrush and Julian were studied for their individual sugars and inositol contents at harvest time, during and after curing, during storage and after baking. In addition, two carbohydrate extraction methods and a recently published method of determination for polyhydroxy compounds were examined.

The chloroform-methanol extraction was superior to the "standard" ethanol extraction. Complete recoveries of glucose were afforded by both methods; however, the ethanol extraction yielded maltose whereas the chloroform-methanol method did not. The presence of maltose in the ethanol extraction was attributed to the heat used in extraction.

Deionization of sweet potato sugar extracts with MB-3 was undesirable because only small percentages of sugars were recovered. The strongly acidic, strongly basic MB-3 resin apparently "adsorbed" the sugar and alcohol molecules under the conditions used in this study.

Several discrepancies were found in the recently published determination of sugar trimethylsilyl derivatives by gas-liquid chromatography. Although it was reported

that the quantity of the TMS product formed was essentially independent of time, at least six hours were necessary to completely form the penta-o-trimethylsilyl derivatives of fructose. The penta-o-trimethylsilyl derivatives of glucose were formed within five minutes as reported in the literature.

Anomerization from alpha- to beta-fructose under the conditions of this study occurred after the introduction of the TMS reactants. This was not in agreement with the literature.

The results of the curing, storage and baking treatments on the four sweet potato varieties may be summarized as follows:

1. The reducing sugars glucose and fructose increased significantly as a result of curing in Centennial and Goldrush roots.
2. Six months of storage tended to increase the glucose and fructose contents in Centennial and Goldrush roots.
3. The glucose and fructose levels in Acadian and Julian roots remained relatively unchanged throughout curing and storage.
4. During baking, all varieties increased in glucose and fructose.
5. Maltose was not present in raw roots; however, after baking it was the sugar in most abundance.

6. Curing resulted in a significant increase in the sucrose content of the four varieties used in this study.

7. The sucrose content of the four varieties increased significantly from curing through 4.5 months of storage.

8. During baking, Centennial, Goldrush and Julian roots decreased significantly in sucrose contents.

9. Acadian roots contained significantly more inositol than the other varieties used in this study.

The relationships between sugar and inositol changes during curing, storage and baking may be summarized as follows:

1. Glucose and fructose were positively correlated with reducing sugar at the .01 level of significance.

2. A highly significant positive correlation existed between glucose and fructose.

3. A significant negative correlation existed between glucose and inositol.

4. Sucrose was positively correlated at the .05 level of significance with inositol.

After baking, reducing sugars and sucrose were positively correlated with maltose at the .01 level of significance.

As expected, the four varieties used in this study responded differently, in some instances, to the conditions of curing, storing and baking.

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VITA

Roy Eric McDonald was born on November 19, 1942 in Clifton, Texas. He obtained his elementary education at St. Anthony parochial school in Harlingen, Texas. After completing his high school education at San Benito High, he entered Texas A&M University in September, 1960. Upon receipt of the Bachelor of Science degree in Agronomy in May, 1964, he pursued the Master of Science degree in Horticulture at Texas A&M University, which he received in May, 1966.

In May, 1966, he accepted the position of Research Associate and registered as a part time student in the Department of Horticulture at Louisiana State University. In June, 1968, he resigned his position as Research Associate, was granted a Research Assistantship, and devoted full time to completing the requirements for the degree of Doctor of Philosophy for which he is now a candidate in January, 1970.

EXAMINATION AND THESIS REPORT

Candidate: Roy Eric McDonald

Major Field: Horticulture





Title of Thesis: Some Effects of Post Harvest Handling Methods on Sugars
and Inositol in the Sweet Potato (Ipomoea batatas Poir.)

Approved:


Major Professor and Chairman


Dean of the Graduate School

EXAMINING COMMITTEE:

Date of Examination:

August 4, 1969